blow moulding

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(19) THE PATENT OFFICE LONDON

(54) PROCESS FOR THE PRODUCTION OF HOLLOW PLASTICS ARTICLES

(71) We, MESSER GRIESHEIM GMBH, a Company organised under the laws of Germany, of D—6000 Frankfurt/Main, Hanauer Landstrasse 330, Federal Republic of Germany, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an improved process for the production of hollow plastics articles by a blow moulding process. In this process, an endless plastics tube is extruded, and whilst still in a warm mouldable condition, is passed into a blow mould. The open ends of the tube are squeezed off heated and sealed. The piece of tube between the sealed end points is blown up and applied against the wall of the blow mould. After this, the hollow plastics article so moulded is cooled and taken out of the mould.

Gases are introduced into the hollow article to be formed through a blow mandrel. Several of such processes are known for blowing up and cooling hollow plastics articles. According to an old process, the moulding is expanded by compressed air, and is then scavenged with compressed air until it is cooled to such a point that it can be taken out of the mould. In this process, the production cycle time is comparatively long, because of the nature of the cooling action of the compressed air. Therefore attempts have already been made to reduce the cooling period by cooling the mould by circulating water or brine around it, or by spraying liquid carbon dioxide into the moulding. Although it has been possible in this way to reduce the production cycle time, this method of cooling nevertheless suffers from a number of disadvantages. On the one hand, two feed pipes are required, namely one for the compressed air and one for the liquid carbon dioxide. As a result of this, the blow mandrel acquires a very large diameter and therefore, in practice, when small hollow articles are being formed it cannot be inserted. The expenditure required for control units is doubled, because both the compressed air and also the liquid carbon dioxide must be forced into the moulding in accordance with the working rhythm of the moulding system. Furthermore, the carbon dioxide must be prevented from being precipitated in the form of snow, that is to say, it is necessary to operate at above the triple point of carbon dioxide, that is to say above a pressure of 4.2 atmospheres gauge. In addition, it is necessary to prevent liquid carbon dioxide from reaching the inner wall of the hollow plastics article, because this could give rise to defects in the material as a result of the cold shock. The processes mentioned have been described, for example, in German Published Patent Application 1,272,525 and German Laid-Open Specification 1,479,162. In this connection, it has also been suggested that instead of working with liquid carbon dioxide, liquid nitrogen should be used in order to shorten the working cycle still further, because the cooling action of liquid nitrogen is far more intensive than that of liquid carbon dioxide. Hitherto, it has not been possible for the use of liquid nitrogen to become widespread because, when using it, material damage as a result of cold shock is unavoidable. In German Laid-Open Specification 1,479,162 it has therefore been proposed that liquid nitrogen should not be injected directly through the blow mandrel but that it should either be sprayed into the scavenging air channel or should be used solely as a coolant for the scavenging air in a heat exchanger. It is obvious that in this way the extreme cooling action of the liquid nitrogen cannot be fully utilised, and the process is therefore uneconomical. Another disadvantage is that it is necessary to operate with two circuits,

namely a compressed air circuit and a nitrogen circuit.

German Laid-Open Specification 1,805,011 also discloses a method of spraying the coolant directly into the moulding, that is to say without first expanding the moulding by means of compressed air. It is obvious that this cannot be done with liquid carbon dioxide, because carbon dioxide snow will be formed as a result of the fall in pressure which unavoidably occurs at the commencement of the injection. If liquid nitrogen is used in an apparatus according to German Laid-Open Specification 1,805,011, obviously liquid nitrogen comes into contact with the inner wall of the moulding, which has the disadvantages mentioned above. Accordingly, in German Laid-Open Specification 1,805,011 it is also preferred that the moulding should first of all be expanded with compressed air. Direct injection of a liquefied gas as coolant, can therefore be considered, at any rate in the case of high-boiling gases, for example a few fluorinated hydrocarbons.

An object of the present invention is to provide a process for the production of hollow plastics articles by the above blowing process, wherein it is possible to carry out both the expanding and cooling of the hollow article with a single medium, a low-temperature liquefied gas, which enters the moulding through a single pipe. In this way, with processes of this kind, the subdivision into a blowing phase and a cooling phase using different media, which was usual hitherto, is replaced by a single phase with a single medium.

According to the invention we provide a process for the production of a hollow plastics article by blow moulding, which comprises expanding and cooling a plastics preform by means of a low boiling point liquefied gas which flows into the preform through a single pipe provided with a valve and a blow mandrel, wherein at the beginning of the inflow phase the liquefied gas evaporates when passing through the pipe, valve and blow mandrel and subsequently only partially evaporates as a result of cooling of said pipe valve and blow mandrel, and at the end of the inflow phase enters the preform in the liquid state.

To effect the change from the gaseous state to the liquid state use is made of heat storage capacity already existing in the section of pipe between the valve controlled according to the cycle of the system and the tip of the blow mandrel. The low-boiling gases used are mainly nitrogen and argon, but it is also possible to use in the process according to the invention other gases, for example low-boiling fluorinated hydrocarbons. Consequently, whenever nitrogen is mentioned hereinafter it is not meant that the invention is to be restricted to the use of nitrogen.

Before the commencement of the blowing phase, evaporated, i.e. gaseous, nitrogen at a comparatively high temperature is located in the blowing mandrel and in the piece of piping between the blowing mandrel and the valve. The nitrogen is evaporated as a result of the radiation of heat from the warm surroundings into the blowing mandrel and into the blowing pipe. At the commencement of the blowing phase, the valve controlled in the working stroke of the system opens and liquid nitrogen flows out of a storage container which is under pressure. Since, however, the blow mandrel and the pipe connected to it are warm, this liquid nitrogen evaporates, accompanied by a marked increase in volume (see Figure 1 of the accompanying drawings) immediately, so that first of all only gaseous nitrogen comes out of the blow mandrel. As a result of this, the moulding is expanded and under certain circumstances it is at this stage brought into its final shape (see Figures 2 and 3 of the accompanying drawings). As a result of the evaporation of the nitrogen, the blow mandrel and the pipe are now cooled to a considerable extent so that the nitrogen is only partially evaporated, and a gas/liquid mixture flows into the moulding, which is already expanded to a large extent, and cools this. It is very advantageous if, in this final phase, the pressure on the plastics hollow body is released whilst allowing the liquid nitrogen to continue to flow in (see Figure 4 of the accompanying drawings). This can be done, for example, by lifting the blow mandrel or via a three-way valve. As a result of the sudden drop in pressure, the liquid nitrogen coming out of the blow mandrel is atomised very finely, so that there is no danger of a cold shock to the material. The disadvantages of a cold shock, however, in this end phase, are not so great, because the plastics hollow body has already reached its final shape. It is far more important to ensure that during the first inflow of liquid nitrogen, no liquid droplets come into direct contact with the inner wall of the moulding. For this purpose, the cross-section of outlet of the blow mandrel and the storage pressure in the nitrogen tank are adjusted in such a way that, at the commencement of the blowing phase, the gaseous nitrogen comes out of the blow mandrel approximately at the speed of sound. As soon as the first liquid droplets appear in this gas flow, this is atomised at the outlet from the blow mandrel, and in this way it is more finely divided than would be possible with a spray nozzle. This fine atomisation ensures that, at the commencement of the cooling, no liquid nitrogen impinges on the inner wall of the moulding.

In the device for carrying out the process according to the invention, it is necessary to ensure that the blow mandrel and the piece of pipe between the blow mandrel and the valve possess a heat storage capacity sufficient to cause evaporation of the liquefied gas at the beginning of the inflow phase so that at the commencement of the inflow phase a sufficient quantity of nitrogen can evaporate. The materials from which the blow mandrel and pipe are made must therefore have a high specific heat capacity and good thermal conductivity. If the heat storage capacity is too small, then it is necessary to heat the blow mandrel and possibly also the pipe (see Figure 5) (item 8). Furthermore, it is important to situate the valve, which is controlled in the working tempo of the system, as close as is constructionally possible to the blow mandrel. This ensures that after the closing of the valve, only a small quantity of liquid nitrogen is located in the pipe and in the blow mandrel. This small quantity evaporates very rapidly so that the blow mandrel and the pipe rapidly store heat once again.

Where a very long plastics hollow article is being moulded, it is advantageous to design the outlet aperture of the blow mandrel as a Laval nozzle. Where large plastics hollow bodies are being made, it may also be advantageous to provide a number of outlet apertures in the blow mandrel.

In comparison with the known processes, the process according to the invention has the following advantages:

The coldness content of the deep-cooled liquefied gas can be fully utilised, because it reaches the moulding directly in the liquid state, that is to say without being, for example, sprayed into the blowing air, or serving as a coolant medium in a heat exchanger. Although a low-boiling liquefied gas is used, it is not necessary first of all to expand the moulding via a separate pipe with a gaseous medium. The plant is therefore simplified, because no separate pipelines are necessary. The rhythm time is considerably reduced because the blowing phase and the cooling phase are no longer separated from one another, but pass from one to the other. At the commencement of the cooling, the liquid carried along in the gas stream is atomised, the tiny droplets are also further transported by the gas flow inside the moulding and they cool this continuously by evaporation of the droplets themselves. Therefore it is unnecessary that the adaptation of the blow mandrel to the shape of the hollow body be so accurate as in the case when the liquid gas is introduced through a spraying nozzle. Also, the pressure release during the last phase of the inflow of the liquid gas reduces the cycle time.

No pumps and fans are necessary for the production of the blow pressure for the compressed air and the liquid pressure, as for example are needed for carbon dioxide and compressed air. Instead, it is possible to adjust in the storage tank a pressure which can be any pressure desired within wide limits, for example of nitrogen up to 20 atmospheres gauge. As a result of the high speed of the blowing mandrel outlet, because of the comparatively high forward pressure and the strong expansion of volume during the evaporation of the liquefied deep-cooled gas, there is a markedly turbulent flow of the gas in the moulding itself, and consequently an increased transfer of heat. As a second pipe for a separate flowing medium is dispensed with, in the process according to the invention, only a small blow mandrel is required, and consequently the process can also be carried out when it is desired to blow small plastics hollow articles.

An example of an embodiment of the invention will be described with reference to the attached drawings of which:

Figures 1 to 4 show different phases of the expanding and cooling of a plastics hollow body; and

Figure 5 shows, in diagrammatical form, a system for carrying out the process according to the invention.

Referring to the drawings, in the phases represented in Figures 1 to 4, Figure 1 shows the condition at the commencement of the working stroke. From below mandrel 3 there issues gaseous nitrogen and this expands a plastics preform 1.

In Figure 2 the plastics preform 1 has already practically reached its final shape, and the first droplets of liquid nitrogen form.

In Figure 3 the plastics preform 1 has reached its final shape and rests against the two-part mould 2. Increasingly large quantities of liquid nitrogen flow in through the blow mandrel 3.

Figure 4 shows the end phase of the working stroke. The blow mandrel is lifted away whilst liquid nitrogen is still flowing in. As a result of the sudden fall in pressure, the liquid nitrogen issuing from the blow mandrel is atomised so finely that there is no risk of a cold shock to the material.

Figure 5 shows the entire installation in a simplified form. A hollow plastics article 1 is already expanded in a two-part mould 2. Via a blow mandrel 3, a piece of piping 4, a valve 5 which is controlled according to the machine stroke, and a pipe 6, liquid nitrogen is fed to the hollow plastics article 1 from a storage unit 7. The piece of piping 4 and the blow mandrel 3 have a high heat storage

capacity. The blow mandrel 3 can be lifted from the mould 2 in a known manner for releasing the air. Around the piece of piping 4, there is arranged a heating unit 8, which ensures that in any case, at the commencement of the blowing only gaseous nitrogen comes out of the blow mandrel 3. An outlet valve 9 makes it possible, when starting up the machine, to scavenge the pipe with nitrogen and to cool it to the operating temperature.

WHAT WE CLAIM IS:—

1. A process for the production of a hollow plastics article by blow moulding, which comprises expanding and cooling a plastics preform by means of a low boiling point liquefied gas which flows into the preform through a single pipe provided with a valve and a blow mandrel, wherein at the beginning of the inflow phase the liquefied gas evaporates when passing through the pipe, valve and blow mandrel and subsequently only partially evaporates as a result of cooling of said pipe, valve and blow mandrel, and at the end of the inflow phase enters the preform in the liquid state.

2. A process in accordance with Claim 1, wherein, during the end phase of the inflow, in which the liquefied gas flows through the blowing mandrel, the pressure on the hollow plastics article is released.

3. A process in accordance with Claim 2, wherein the pressure release is effected by raising the blow mandrel to create an annular gap at the mouth of the blow mould.

4. A process in accordance with any one of Claims 1 to 3, wherein at the commencement of outflow from the blow mandrel, the heated gas located in the section of piping between the valve and the outlet of the blow mandrel and also the gas flowing into and evaporating in this section of pipe comes out of the blowing mandrel approximately at the speed of sound.

5. A process in accordance with one of Claims 1 to 4, wherein the low boiling point liquefied gas used is nitrogen or argon.

6. A blow moulding machine for carrying out the process according to any one of Claims 1 to 5, which comprises a blow mould for a hollow plastics article, a blow mandrel projecting into the mould, which mandrel is connected by a pipe and a valve controlled according to the stroke of the machine with a tank containing a low boiling point liquefied gas, wherein the pipe between the valve and the blow mandrel, and also the blow mandrel itself both have a heat storage capacity sufficient to cause evaporation of the liquefied gas at the beginning of the inflow phase.

7. A device in accordance with Claim 6, wherein the pipe between the valve and the blow mandrel and/or the blow mandrel itself is provided with a heater.

8. A device in accordance with Claims 6 or 7, wherein the pipe between the valve and the blow mandrel is designed to be as short as is constructionally possible so as to retain the minimum amount of liquid nitrogen after the valve is closed.

9. A device in accordance with any one of Claims 6 to 8, wherein the outlet aperture of the blow mandrel is designed as a Laval nozzle.

10. A device in accordance with Claim 6 and substantially as described herein with reference to the accompanying drawings.

11. A process for the production of hollow plastics articles substantially as described herein with reference to the accompanying drawings.

12. Hollow plastics articles whenever produced by the process of any one of claims 1—5 or 11.

13. Hollow plastics articles whenever produced by using a device as claimed in any one of claims 6—10.

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1397513 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

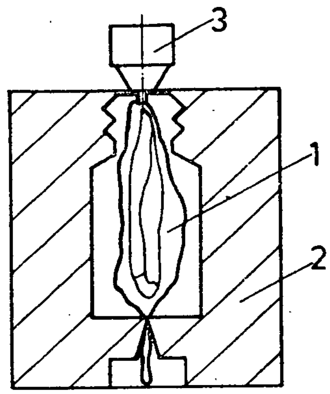

Fig. 1

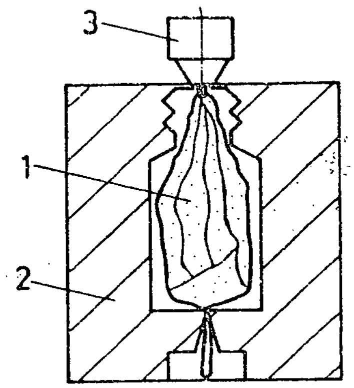

Fig. 2

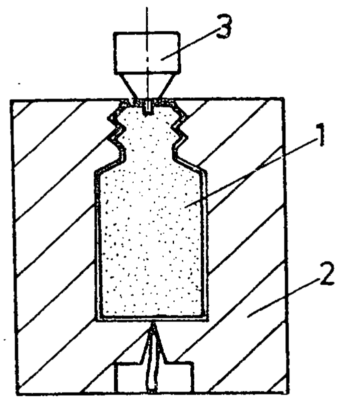

Fig. 3

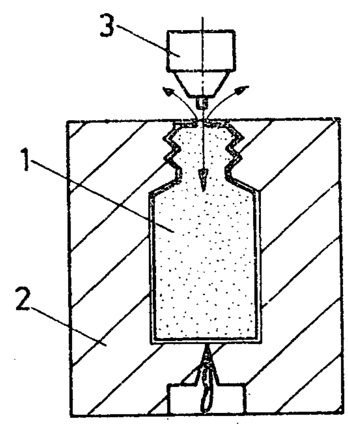

Fig. 4

1397513 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

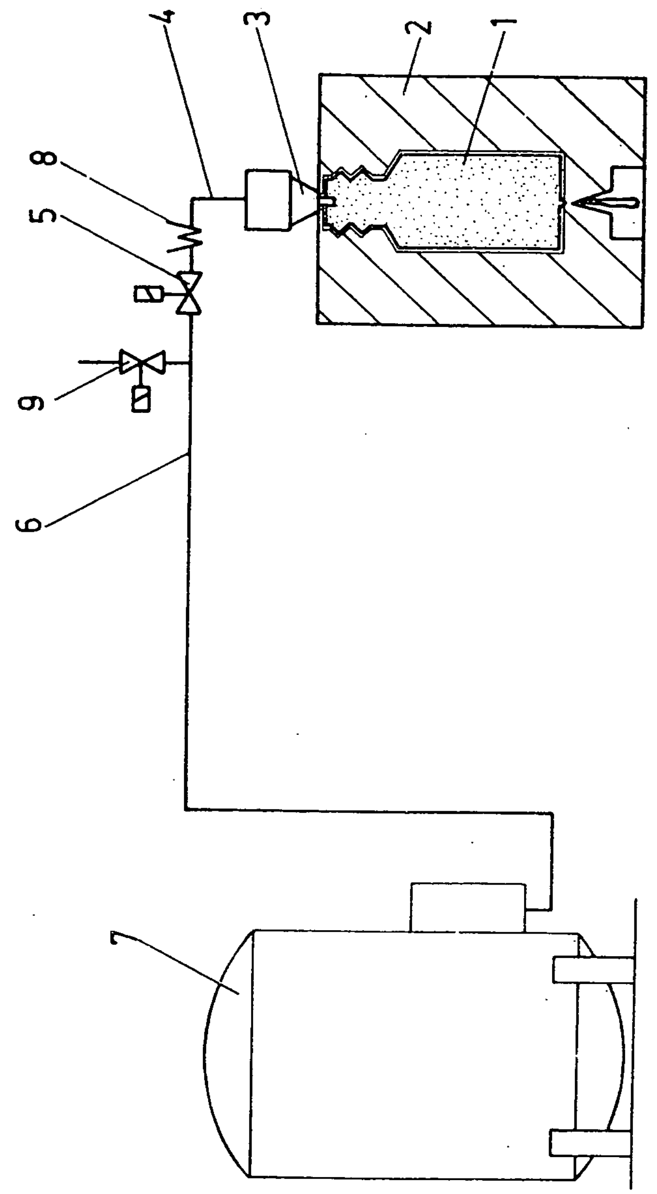

Fig. 5